

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	1	("4051300" "4838904" "5076935" "5891572" "5911880")("3095258" "488223" "5980795").PN.	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:11
L2	12	("4051300" "4838904" "5076935" "5891572" "5911880""3095258" "4882223" "5980795").PN.	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:28
L3	0	2 and ethoxy	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:29
L4	0	2 and propyl acetate	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:29
L5	0	dibasic esters and 2	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:29
L6	0	hollow fiber and "ethoxy propyl acetate"	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:30
L7	1135	hollow fiber and ethoxy	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:30
L8	0	7 and ethoxypropylacetate	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:31
L9	0	7 and "ethoxy propylacetate"	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:31
L10	0	7 and "ethoxy propyl acetate"	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:31
L11	0	7 and "ethoxy alkyl acetate"	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:32
L12	840	7 and acetate	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:32
L13	593	12 and propyl	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:32
L14	593	12 and propyl acetate	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:33
L15	89	14 and asymmetric	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:36

L16	0	15 and skin and bore same propyl acetate	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:33
L17	7	15 and bore fluid	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:34
L18	3	17 and bore fluid same propyl and acetate	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:34

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L38: Entry 3 of 15

File: USPT

Dec 16, 2003

DOCUMENT-IDENTIFIER: US 6663805 B1

TITLE: Process for making hollow fiber mixed matrix membranes

Brief Summary Text (21):

A diverse variety of polymers can be used for the substrate. Representative substrate polymers include polysulfone, polyether sulfone, polyamide, polyimide, polyetherimide, polyesters, polycarbonates, copolycarbonate esters, polyethers, polyetherketones, polyvinylidene fluoride, polybenzimidazoles, polybenzoxazoles, cellulosic derivatives, polyazoaromatics, poly(2,6-dimethylphenylene oxide), polyarylene oxide, polyureas, polyurethanes, polyhydrazides, polyazomethines, cellulose acetates, cellulose nitrates, ethyl cellulose, brominated poly(xylylene oxide), sulfonated poly(xylylene oxide), polyquinoxaline, polyamideimides, polyamide esters, blends thereof, copolymers thereof, substituted materials thereof and the like. This should not be considered limiting since any material which can be fabricated into an anisotropic substrate membrane may find utility as the substrate layer of the present invention. Preferred materials for the substrate layer include polysulfone, polyethersulfone, polyetherimide, polyimide and polyamide compositions.

Brief Summary Text (23):

A wide range of polymeric materials have desirable selectively gas permeating properties and can be used as the continuous phase polymer gas separating layer. Representative materials include polyamides, polyimides, polyesters, polycarbonates, copolycarbonate esters, polyethers, polyetherketones, polyetherimides, polyethersulfones, polysulfones, fluorine-substituted ethylene polymers and copolymers such as polyvinylidene fluoride, tetrafluoroethylene, copolymers of tetrafluoroethylene with perfluorovinylethers or with perfluorodioxoles, polybenzimidazoles, polybenzoxazoles, polyacrylonitrile, cellulosic derivatives, polyazoaromatics, poly(2,6-dimethylphenylene oxide), polyphenylene oxide, polyureas, polyurethanes, polyhydrazides, polyazomethines, polyacetals, cellulose acetates, cellulose nitrates, ethyl cellulose, styrene-acrylonitrile copolymers, brominated poly(xylylene oxide), sulfonated poly(xylylene oxide), tetrahalogen-substituted polycarbonates, tetrahalogen-substituted polyesters, tetrahalogen-substituted polycarbonate esters, polyquinoxaline, polyamideimides, polyamide esters, blends thereof, copolymers thereof, substituted materials thereof, and the like. In addition, suitable gas separating layer membrane materials may include those found useful as the dense separating layer of composite gas separation membranes. These materials include polysiloxanes, polyacetylenes, polyphosphazenes, polyethylenes, poly(4-methylpentene), poly(trimethylsilylpropyne), poly(trialkylsilylacetylenes), polyureas, polyurethanes, blends thereof, copolymers thereof, substituted materials thereof, and the like. It is further anticipated that polymerizable substances, that is, materials which cure to form a polymer, such as vulcanizable siloxanes and the like, may be suitable gas separating layers for the multicomponent gas separation membranes of the present invention. Preferred materials for the dense gas separating layer include aromatic polyamide and aromatic polyimide compositions.

Brief Summary Text (44):

"Displaceable radical" means an active functional group capable of reacting with silanol groups on the molecular sieve such that X is displaced leaving the

molecular sieve bonded to the monofunctional organosilicon compound at the X--Si bond position. Preferably, the displaceable radical can be a halogen, a hydroxyl group, or an ester or alkoxy radical having from 1-8 carbon atoms. Any halogen, i.e., fluorine, chlorine, iodine, or bromine atom can be used. A representative ester is the acetoxy radical. Illustrative examples of alkoxy radicals of substituent X include methoxy, ethoxy, n-propoxy and t-butoxy radicals.

Brief Summary Text (54):

Although materials selection and treatment represent an important aspect of this invention, processing the materials to fabricate hollow fiber membranes constitutes another important aspect. A typical procedure for producing a composite mixed matrix hollow fiber selectively gas permeable membrane according to this invention involves simultaneously coextruding a sheath suspension of mixed matrix composition and a core solution by utilizing a composite hollow fiber spinnerette design to form a nascent composite hollow fiber membrane which travels through an air gap into a nonsolvent coagulation bath, followed by windup on a drum, roll or other suitable device. Various additional steps such as, post treatment, packaging, and storage may be utilized. It should be noted that a monolithic, i.e., non-composite hollow fiber can optionally be fabricated as above by leaving out steps associated with forming the core solution.

[Previous Doc](#)

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L52: Entry 1 of 1

File: JPAB

Oct 10, 2001

DOCUMENT-IDENTIFIER: JP 2001279136 A

TITLE: PEELING COMPOSITION APPLICABLE IN ARCHITECTURAL FIELD

Abstract Text (1):

PROBLEM TO BE SOLVED: To obtain a peeling composition for peeling especially an outer waterproofing coat or a thin membrane in architectural industry.

Abstract Text (2):

SOLUTION: This composition comprises (A) at least one dibasic ester, (B) at least one aprotic amphoteric solvent, (C) at least one cosolvent, (D) a combination of softeners, and (E) an additive selected from an organic filler, a cellulose thickner and a dispersant.



[Previous Doc](#)      [Next Doc](#)      [Go to Doc#](#)

## Freeform Search

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	EPO Abstracts Database
	JPO Abstracts Database
	Derwent World Patents Index
	IBM Technical Disclosure Bulletins

<b>Term:</b>	L56 and hollow fiber	 
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<b>Display:</b>	<input type="text" value="10"/> Documents in <b>Display Format:</b> <input type="text" value="CIT"/> Starting with Number <input type="text" value="1"/>
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### Search History

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**DATE:** Monday, January 09, 2006   [Printable Copy](#)   [Create Case](#)

#### Set Name Query

side by side

#### Hit Count Set Name

result set

*DB=USPT; PLUR=YES; OP=ADJ*

<u>L57</u>	L56 and hollow fiber	10	<u>L57</u>
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<u>L56</u>	ethoxy same propyl same acetate	921	<u>L56</u>
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*DB=JPAB; PLUR=YES; OP=ADJ*

<u>L55</u>	membrane and ethoxy propyl acetate	0	<u>L55</u>
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<u>L54</u>	ethoxy propyl acetate	0	<u>L54</u>
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<u>L53</u>	ethoxy propylacetate	0	<u>L53</u>
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<u>L52</u>	dibasic esters and membrane	1	<u>L52</u>
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<u>L51</u>	L49 and dibasic same esters	0	<u>L51</u>
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*DB=USPT; PLUR=YES; OP=ADJ*

<u>L50</u>	L49 and dibasic same esters	11	<u>L50</u>
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<u>L49</u>	L48 and dibasic	17	<u>L49</u>
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<u>L48</u>	L47 and polymers and membranes	159	<u>L48</u>
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<u>L47</u>	non-solvents same esters	756	<u>L47</u>
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<u>L46</u>	membrnes and non-solvents and dibasic same esters	0	<u>L46</u>
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<u>L45</u>	L44 and membrane	0	<u>L45</u>
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<u>L44</u>	L42 and polymer	3	<u>L44</u>
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<u>L43</u>	L42 and polysulfone	0	<u>L43</u>
<u>L42</u>	non-solvents same dibasic esters	3	<u>L42</u>
<u>L41</u>	dibasic esters and membrane and nonsolvent	0	<u>L41</u>
<u>L40</u>	dibasic esters same nonsolvent	0	<u>L40</u>
<u>L39</u>	nonsolvent and membrane and dibasic esters	0	<u>L39</u>
<u>L38</u>	polysulfone and nonsolvents and ethoxy	15	<u>L38</u>
<u>L37</u>	L36 and ethoxy	2	<u>L37</u>
<u>L36</u>	bore fluid and hollow fiber and nonsolvents and acetates	16	<u>L36</u>
<u>L35</u>	l30 and propyl acetates	3	<u>L35</u>
<u>L34</u>	L30 and dibasic	1	<u>L34</u>
<u>L33</u>	L30 and dibasic same ester	0	<u>L33</u>
<u>L32</u>	L30 and dibasic same esters	0	<u>L32</u>
<u>L31</u>	L30 and dibasic esters	0	<u>L31</u>
<u>L30</u>	210/500.41.ccls.	371	<u>L30</u>
<u>L29</u>	21/500.41.ccls.	0	<u>L29</u>
<u>L28</u>	L27 and membranes	51	<u>L28</u>
<u>L27</u>	dibasic esters	750	<u>L27</u>
<u>L26</u>	L25 and hollow fiber	1	<u>L26</u>
<u>L25</u>	membrane and dibasic esters	51	<u>L25</u>
<u>L24</u>	L21 and dibasic esters	0	<u>L24</u>
<u>L23</u>	L21 and methoxy propylacetate	0	<u>L23</u>
<u>L22</u>	L21 and ethoxy propyl acetate	0	<u>L22</u>
<u>L21</u>	l19 and ethoxy	23	<u>L21</u>
<u>L20</u>	L19 and l13	0	<u>L20</u>
<u>L19</u>	264/41.ccls.	1245	<u>L19</u>
<u>L18</u>	L17 and l13	0	<u>L18</u>
<u>L17</u>	210/500.23.ccls.	733	<u>L17</u>
<u>L16</u>	210.500.23.ccls.	0	<u>L16</u>
<u>L15</u>	210/500.23.ccls.3	0	<u>L15</u>
<u>L14</u>	L13 and bore fluid same dibasic ester	0	<u>L14</u>
<u>L13</u>	l1 and dibasic ester	650	<u>L13</u>
<u>L12</u>	L11 and deb-4	0	<u>L12</u>
<u>L11</u>	hollow fiber and membrane	7440	<u>L11</u>
<u>L10</u>	hollow fiber membranes and dibasic esters	1	<u>L10</u>
<u>L9</u>	bore fluid same dibasic esters	0	<u>L9</u>
<u>L8</u>	bore fluid same ethoxy	0	<u>L8</u>
<u>L7</u>	l3 and propyl acetate	2	<u>L7</u>
<u>L6</u>	L3 and ethoxy propylacetates	0	<u>L6</u>
<u>L5</u>	L3 and ethoxy propyl acetate	0	<u>L5</u>
<u>L4</u>	L3 and ethoxy propylacetate	0	<u>L4</u>
<u>L3</u>	membrane and hollow fiber and ethoxy	234	<u>L3</u>

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
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L2	12	("4051300" "4838904" "5076935" "5891572" "5911880" "3095258" "488223" "5980795").PN.	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:28
L3	0	2 and ethoxy	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:29
L4	0	2 and propyl acetate	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:29
L5	0	dibasic esters and 2	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:29
L6	0	hollow fiber and "ethoxy propyl acetate"	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:30
L7	1135	hollow fiber and ethoxy	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:30
L8	0	7 and ethoxypropylacetate	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:31
L9	0	7 and "ethoxy propylacetate"	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:31
L10	0	7 and "ethoxy propyl acetate"	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:31
L11	0	7 and "ethoxy alkyl acetate"	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:32
L12	840	7 and acetate	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:32
L13	593	12 and propyl	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:32
L14	593	12 and propyl acetate	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:33
L15	89	14 and asymmetric	USPAT; EPO; DERWENT	AND	ON	2006/01/09 10:33



L16	0	15 and skin and bore same propyl acetate	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:33
L17	7	15 and bore fluid	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:34
L18	3	17 and bore fluid same propyl and acetate	USPAT; EPO; DERWENT	AND	ON	2006/01/09 09:34
L19	499	phenoxy resin and hollow fiber and ester	USPAT; EPO; DERWENT	AND	ON	2006/01/09 10:34
L20	55	19 and dibasic ester	USPAT; EPO; DERWENT	AND	ON	2006/01/09 10:42
L21	32	bore fluid same dibasic ester	USPAT; EPO; DERWENT	AND	ON	2006/01/09 10:42
L22	18	21 and hollow fiber	USPAT; EPO; DERWENT	AND	ON	2006/01/09 10:43
L23	14	"4720345"	USPAT; EPO; DERWENT	AND	ON	2006/01/09 10:48
L24	0	23 and dibasic ester	USPAT; EPO; DERWENT	AND	ON	2006/01/09 10:48
L25	0	23 and dibasic ester	USPAT; EPO; DERWENT	AND	ON	2006/01/09 10:48
L26	5	23 and ester	USPAT; EPO; DERWENT	AND	ON	2006/01/09 10:49
L27	0	26 and dibasic	USPAT; EPO; DERWENT	AND	ON	2006/01/09 10:49
L28	0	22 and acetate and ethoxy	USPAT; EPO; DERWENT	AND	ON	2006/01/09 10:50
L29	0	23 and dibasic	USPAT; EPO; DERWENT	AND	ON	2006/01/09 10:50
L30	8	23 and acetate	USPAT; EPO; DERWENT	AND	ON	2006/01/09 10:57
L31	6	hollow fiber and dimethylsuccinate	USPAT; EPO; DERWENT	AND	ON	2006/01/09 10:59

L32	191	hollow fiber and glutarate	USPAT; EPO; DERWENT	AND	ON	2006/01/09 11:00
L33	129	hollow fiber and dimethyl glutarate and 32	USPAT; EPO; DERWENT	AND	ON	2006/01/09 11:01
L34	1	33 and bore fluid	USPAT; EPO; DERWENT	AND	ON	2006/01/09 11:02
L35	25	non-solvent same dimethyl succinate	USPAT; EPO; DERWENT	AND	ON	2006/01/09 11:05
L36	0	25 and hollow fiber	USPAT; EPO; DERWENT	AND	ON	2006/01/09 11:03
L37	40	polysulfone membrane and solvent same dimethyl succinate	USPAT; EPO; DERWENT	AND	ON	2006/01/09 11:09
L38	617	hollow fiber and dimethyl succinate	USPAT; EPO; DERWENT	AND	ON	2006/01/09 11:09
L39	136	38 and polysulfone	USPAT; EPO; DERWENT	AND	ON	2006/01/09 11:10
L40	41	39 and bore fluid	USPAT; EPO; DERWENT	AND	ON	2006/01/09 11:11
L41	9	210/500.23 and dimethyl succinate	USPAT; EPO; DERWENT	AND	ON	2006/01/09 11:13
L42	0	210/500.23 and "dimethyl succinate"	USPAT; EPO; DERWENT	AND	ON	2006/01/09 11:13
L43	0	210/500.41 and "dimethyl succinate"	USPAT; EPO; DERWENT	AND	ON	2006/01/09 11:13
L44	0	210/500.41 and "dimethyl uccinate"	USPAT; EPO; DERWENT	AND	ON	2006/01/09 11:13
L45	218	membrane and polysulfone and dimethyl succinate	USPAT; EPO; DERWENT	AND	ON	2006/01/09 11:14
L46	68	45 and hollow fiber	USPAT; EPO; DERWENT	AND	ON	2006/01/09 11:14

US-PAT-NO: 5753008

DOCUMENT-IDENTIFIER: US 5753008 A

\*\*See image for Certificate of Correction\*\*

TITLE: Solvent resistant hollow fiber vapor permeation  
and modules

DATE-ISSUED: May 19, 1998

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Friesen; Dwayne T.	Bend	OR	N/A	N/A
McCray; Scott B.	Bend	OR	N/A	N/A
Newbold; David D.	Bend	OR	N/A	N/A
Ray; Roderick J.	Bend	OR	N/A	N/A

ASSIGNEE INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE
Bend Research, Inc.	Bend	OR	N/A	N/A	02

APPL-NO: 08/501403

DATE FILED: July 12, 1995

INT-CL-ISSUED: [06] B01D053/22 , B01D069/08 , B01D061/36

US-CL-ISSUED: 95/45 , 96/10 , 96/12 , 210/321.89 , 210/500.23 , 210/500.39  
, 210/640 , 264/48 , 264/171.26

US-CL-CURRENT: 95/45, 210/321.89 , 210/500.23 , 210/500.39 , 210/640  
, 264/171.26 , 264/48 , 96/10 , 96/12

FIELD-OF-CLASSIFICATION-SEARCH: 210/640; 210/638 ; 210/500.39 ; 210/651  
; 210/321.8 ; 210/321.89 ; 210/500.23  
; 210/500.33 ; 210/508 ; 210/650 ; 95/45

; 95/52 ; 96/10 ; 96/12 ; 96/13 ; 427/245  
; 264/41 ; 264/48 ; 264/171.26 ; 264/171.28

**\*\*See application file for complete search history\*\***

**REF-CITED:**

U.S. PATENT DOCUMENTS				
PAT-NO	ISSUE-DATE	PATENTEE-NAME		US-CL
N/A	April 1984	Makino et al.	210/500.2	N/A
N/A	October 1989	Karakane et al.	N/A	N/A
N/A	October 1989	Kikukawa et al.	N/A	N/A
N/A	December 1989	Perry et al.	210/651	N/A
N/A	April 1990	Van Wijk et al.	N/A	N/A
N/A	May 1990	Kohn	N/A	N/A
N/A	October 1990	Blume et al.	N/A	N/A
N/A	December 1990	Nakagawa et al.	N/A	N/A
N/A	March 1991	Friesen et al.	95/52	N/A
N/A	August 1991	Linder et al.	210/651	N/A
N/A	April 1992	Friesen et al.	95/52	N/A
N/A	October 1992	Parker et al.	96/10	N/A
N/A	November 1992	Newbold et al.	95/52	N/A
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March 1997

Friesen et al.

95/45

N/A

N/A

## OTHER PUBLICATIONS

Rautenbach et al., "Vapor Permeation of Water-Organic Mixtures, Module & Process Design," Proc. 3d Int'l. Conf. Pervaporation (1988).

Suemsatsu et al., "Separation of Ethanol-Water Mixtures by Vapor Permeation Through Cellophane " 14 337 (1989).

ART-UNIT: 136

PRIMARY-EXAMINER: Drodge; Joseph W.

ATTY-AGENT-FIRM: Chernoff, Vilhauer, McClung & Stenzel, LLP

## ABSTRACT:

A vapor permeation method and apparatus for removing a vapor from a vaporous feed stream, the method and apparatus utilizing highly solvent-resistant composite hollow fiber and a permeate flow countercurrent to the feed flow, wherein the support of the composite is formed by solution casting and has been rendered sufficiently solvent-resistant by a post-casting step to retain at least 20 of its burst pressure when soaked in the solvent used to cast the support.

59 Claims, 0 Drawing figures

Exemplary Claim Number: 32

----- KWIC -----

## Abstract Text - ABTX (1):

A vapor permeation method and apparatus for removing a vapor from a vaporous feed stream, the method and apparatus utilizing highly solvent-resistant composite hollow fiber and a permeate flow countercurrent to the feed flow, wherein the support of the composite is formed by solution casting and has been rendered sufficiently solvent-resistant by a post-casting step to retain at least 20 of its burst pressure when soaked in the solvent used to cast the support.

TITLE - TI (1):

Solvent resistant hollow fiber vapor permeation and modules

Brief Summary Text - BSTX (2):

Vapor permeation is a -based process that can be used to separate mixtures of vapors. In an example of such a process, a vaporous mixture of ethanol containing low concentrations of water is fed to the feed side of a while a vacuum pump or gaseous sweep stream, usually in combination with a condenser, maintains a sufficiently low partial pressure of water on the permeate side of the to provide a chemical potential gradient of water across the . Water and some ethanol are transported to the permeate side of the to form a vapor-phase permeate.

Brief Summary Text - BSTX (3):

There are three known basic ways to maintain sufficiently low partial pressure of water on the permeate side of a module, namely, by vacuum, by dilution and by countercurrent sweep. Each is explained below.

Brief Summary Text - BSTX (4):

The vacuum method A vacuum pump and condenser are used to reduce the total pressure on the permeate side of the . Since very low pressures are required to maintain the permeate side partial pressure below that of the feed, systems that rely on this method tend to be relatively costly and complex.

Brief Summary Text - BSTX (5):

The dilution method Here, the is designed such that some of the alcohol in the feed stream permeates the diluting the water in the permeate, reducing its partial pressure, and maintaining a driving force. This technique is usually employed with a vacuum pump and condenser on the permeate side of the as in the vacuum method. However, the permeate pressure required is not as low as in the vacuum method due to the dilution effect. There are two primary draw-backs with this method: (1) it lacks versatility in that the rate at which alcohol passes through the is fixed by the characteristics and the operating conditions, and therefore cannot be easily adjusted; and (2) since the permeating feed stream permeates equally along the length of the the feed that permeates near the feed end of the module is "wasted" since the partial pressure of water in the feed is already high and the permeated feed passes along only a portion of the length. As a result, more alcohol must be "leaked" through the than is ideally needed, resulting in a loss in selectivity. However, the dilution method can be effective, especially when the permeate is allowed to flow

countercurrent to the feed stream. In such a case, the permeate passes through the                      and mixes with the permeate gas from the retentate end of the module in such a way as to lower the partial pressure of water in contact with the permeate side of the                      and exits the module in the direction opposite that of the feed flow.

**Brief Summary Text - BSTX (6):**

The countercurrent sweep method A countercurrent sweep stream is used (in conjunction with a vacuum pump and condenser) to maintain a partial pressure driving force across the                      . Because all of the sweep stream enters the permeate at the retentate end of the module, the partial pressure of water is very low and therefore the driving force for transport at the retentate end of the module is maximized. Additionally, because the sweep stream flows countercurrent to the feed stream, the overall driving force for the module is maximized. In addition, the process is quite versatile in that the amount of sweep used may readily be controlled by a valve, making it easy to alter the driving force, allowing for changes in feed composition, temperature, and pressure--all without affecting the overall performance of the system. Thus, the resulting process may be made highly selective, since the optimal amount of sweep to maintain high driving force can be used.

**Brief Summary Text - BSTX (10):**

It is a still further object of the present invention to provide a novel, highly selective composite hollow fiber                      .

**Brief Summary Text - BSTX (13):**

The present invention comprises a novel vapor permeation method and apparatus. The apparatus comprises a bundle of thin-film composite hollow fibers arranged substantially parallel to each other in a chamber or module with a means for removing permeate vapor located near the feed end of the module so as to cause the flow of permeate to be countercurrent to that of the flow of the feed. The composite fibers in the module comprise support fibers of very high permeability and solvent-resistance and a thin, permselective coating on the surface of the support fibers. The support fibers are formed from a polymer dissolved in a solvent and then rendered solvent-resistant in a post-treatment step. In two closely related aspects of the invention, a class of highly selective coatings for the composite fibers has been discovered, as well as an improved method of using the hollow fiber vapor permeation that utilize a countercurrent condensable sweep gas.

**Brief Summary Text - BSTX (16):**

Permeation of water from a wet alcohol feed stream through a                      to the

permeate side of the                      is driven by maintaining a higher water partial pressure on the feed side of the                      relative to the water partial pressure on the permeate side. It is important to maintain a water partial pressure differential across the                      that is as high as possible, as the rate of water transport is proportional to the partial pressure differential. Maintaining a high water partial pressure differential is also important from the standpoint of minimizing                      surface area, since the                      area required is inversely proportional to the water partial pressure differential.

**Brief Summary Text - BSTX (17):**

The partial pressure of water on the feed side of the                      can be increased by heating the feed stream--generally vaporizing the feed at either ambient pressure or higher. As water permeates the                      its partial pressure on the permeate side of the                      will rise unless it is removed from the permeate side of the module.

**Brief Summary Text - BSTX (18):**

The preferred methods of maintaining proper partial pressures on either side of the                      in vapor permeation applications are the dilution method using a countercurrent permeate flow and the countercurrent sweep method.

**Brief Summary Text - BSTX (21):**

(b) a bundle of thin film composite hollow fiber                      arranged substantially parallel to each other in the chamber, each of the composite hollow fiber                      comprising

**Brief Summary Text - BSTX (24):**

(c) sealing means for securing and sealing the bundle of hollow fiber                      to the chamber shell at its feed and retentate ends so as to permit fluid communication with the feed gas.

**Brief Summary Text - BSTX (26):**

(a) contacting a feed stream comprising a first vapor and at least one additional vapor with the feed side of thin film composite hollow fiber                      arranged substantially parallel to each other in a chamber having feed and retentate ends, each of the composite hollow fiber                      comprising

**Brief Summary Text - BSTX (29):**

(b) permitting the first vapor in the feed stream to permeate from the feed to the permeate side of the hollow fiber                      to form a permeate stream enriched in the first vapor and a retentate stream depleted in the first vapor;



and

Brief Summary Text - BSTX (31):

The vaporous mixture comprising the feed stream to the \_\_\_\_\_ selected for the vapor permeation process of the present invention may be derived from a variety of sources, including industrial process vent streams; the vaporous overhead from a distillation or evaporation process; the overhead from a reflux process; vaporized liquids from industrial process liquids; the production of fine chemicals; the production of pharmaceuticals; the recovery or purification of flavors and fragrances from natural products; or from fermentation processes.

Brief Summary Text - BSTX (32):

The separation to be achieved by the vapor permeation process of the present invention may be the removal of water from organics and inorganics; the removal of volatile compounds from water vapor; or the separation of organic and inorganic vapor mixtures. Generally, the \_\_\_\_\_ used is selected so that the minor component of the feed stream is selectively removed; however, the invention need not be so limited.

Brief Summary Text - BSTX (36):

As mentioned above, the support fiber must be highly permeable as well as solvent-resistant. It has been found that this combination of high permeability and high solvent resistance can be obtained by using a support fiber that is formed from a polymer dissolved in a solvent and then rendered solvent-resistant in a post-treatment step. Examples of polymers that can be used for this purpose include poly(amic acids), polyimides, polybenzimidazoles, polyphenylquinoxalanes, and polymers with post-cross-linkable pendant or terminal groups, such as \_\_\_\_\_ polyethersulfones and polyetherimides containing pendant or terminal ethynyl groups.

Brief Summary Text - BSTX (37):

To form the support fiber the polymer can be dissolved in any \_\_\_\_\_ that dissolves the polymer to a concentration of at least 5 wt %. Examples include \_\_\_\_\_ formamide (DMF), dimethylacetamide (DMAc), N-methyl pyrrolidinone (NMP), methylene chloride (MeCl), tetrahydrofuran (THF), toluene, acetone, and sulfoxide (DMSO).

Brief Summary Text - BSTX (40):

In addition, the permeability of the support fiber must be sufficiently high so that it does not provide a major resistance to the flow of permeate through the composite \_\_\_\_\_. This high permeability must be retained even after the

post-treatment step. Generally, the permeability of the fibers to dry nitrogen should be greater than 5 normal cubic meters per square meter per hour per atmosphere driving force ( $\text{Nm}^3/\text{m}^2 \cdot \text{hr} \cdot \text{atm}$ ), and more preferably greater than 50  $\text{Nm}^3/\text{m}^2 \cdot \text{hr} \cdot \text{atm}$ .

Brief Summary Text - BSTX (41):

More specifically, it has been found that a preferred hollow support fiber can be fabricated from a solution of a polyamic acid spun into a nonsolvent by conventional solution-spinning techniques. The micro-porous fiber is then converted to the corresponding polyimide, with retention of porosity, by heat treating at  $>250^\circ\text{C}$ . To achieve the highest degree of solvent resistance while retaining a high permeability the microporous fiber is formed from a copolyimide wherein the copolyimide comprises the imidization reaction product of the condensation reaction product in a solvent of at least three reactants selected from (1) a diamine A or A' and (2) a dianhydride B or B', wherein A, A', B, and B' are selected so that the homopolymer formed from the condensation reaction of A with B, following post treatment, has a glass-transition temperature  $\geq 300^\circ\text{C}$ ; and the homo-polymer formed from the condensation reaction of A' with B', following post treatment, has a resistance to the solvent used to form an asymmetric microporous that is characterized by absorption of  $\leq 50\text{ wt } \%$  after soaking the nonporous polymer in the solvent in pure form at  $20^\circ\text{C}$  for at least 24 hours.

Brief Summary Text - BSTX (42):

The key advantages of such microporous hollow fiber formed by the process of the present invention are that one component (A+B) provides a sufficiently high glass transition temperature to permit retention of the microporous structure of the precursor polyamic acid fiber when converted by heat treatment to the polyimide form; and another component (A'+B'), following post-treatment such as by heat, provides exceptional solvent-resistance. In addition, when the component (A+B) is converted to the polyimide form, in some cases, cross-linking is induced, which is another favorable characteristic for stability and solvent-resistance.

Brief Summary Text - BSTX (43):

The material used as the permselective coating may be virtually any material, provided it has a selectivity of at least 5 for at least one vapor in the feed relative to another vapor in the feed. Here, selectivity is defined as the ratio of the permeability to the first vapor to the permeability of the second vapor, where permeability is defined as the amount of vapor that passes through the per unit area, unit time, unit thickness, and unit driving

force. It has been found that if the selectivity is less than 5, the resulting separation is not efficient, requiring several stages of to effect the separation.

#### Brief Summary Text - BSTX (44):

For the removal of water vapor from other vapors, it is best that the permselective coating material be more permeable to water vapor than to other components in the feed stream. In this case, the material is preferably very hydrophilic. Examples of perm-selective coating materials useful for removing water from organics include polyvinyl alcohol, cellulosic materials, chitin and derivatives thereof, polyurethanes, polyamides, polyamines, poly(acrylic acids), poly(acrylates), poly(vinyl acetates), and polyethers. Other polymers normally viewed as not especially hydrophilic (e.g., polyolefins, polystyrene, and poly-acrylates) can be rendered sufficiently hydrophilic to be useful as materials by incorporating hydrophilic groups such as hydroxyl, amine, carboxyl, ether, sulfonate, phosphonate, quaternary amine, and ester functionalities. Such groups can be incorporated by choosing monomers that contain such groups or by adding them in a post-treatment step such as radiation- or plasma-grafting. Blends and copolymer versions of these materials are also useful. The coating material should also be cross-linked to provide sufficient resistance to swelling or dissolution by components of the feed stream.

#### Brief Summary Text - BSTX (45):

A particularly preferred permselective coating material for dehydration of organics is a blend of poly-vinyl alcohol (PVA) and polyethyleneimine (PEI), wherein the material is cross-linked through the amine groups of the PEI using ethyl by heating to elevated temperatures. By varying the ratio of PVA to PEI or the amount of ethyl cross-linking agent used, the selectivity and permeability of the may be adjusted. This coating will be extremely effective for vapor-permeation applications. However, it will also prove useful for other separations including dehydration of organics by pervaporation; the removal of water vapor from compressed gas streams, such as air and natural gas; and for use in fuel cells, allowing the transport of water while restricting the passage of hydrogen.

#### Brief Summary Text - BSTX (46):

For the removal of volatile compounds from water vapor, the permselective coating is usually, but not always, an elastomeric or rubbery polymer. Examples of materials useful for such separations include natural rubber; nitrile rubber; polystyrene-butadiene copolymers; poly(butadiene-acrylonitrile) rubber; polyurethanes; polyamides; polyacetylenes; poly(trimethylsilylpropyne);

fluoroelastomers; poly(vinylchlorides); poly(phosphazenes), particularly those with organic substituents; halogenated polymers, such as poly(vinylidene fluoride) and poly(tetrafluoroethylene); and polysiloxanes, including silicone rubber. Blends and copolymer versions of these materials are also useful. Ion-exchange and composites may also be used for some applications. A particularly preferred coating for the removal of volatile compounds from water vapor is poly(dimethyl-siloxane) and derivatives thereof.

#### Brief Summary Text - BSTX (47):

For separation of organic mixtures, the choice of material will depend on the organic vapors being separated. Many of the polymers listed above for the dehydration of organics or the removal of volatile organics from water vapor will work well for separating certain organic mixtures. In particular, it is common to use copolymers for separating organics since the ratio of the so-called "hard" and "soft" segments can easily be adjusted to provide the desired selectivity.

#### Detailed Description Text - DETX (16):

This module was then tested using a vaporous feed stream of 20.3 wt % water in isopropyl alcohol (IPA) at 91.degree. C. A vacuum pump/condenser was used to reduce the total pressure on the permeate side of the hollow fiber to 0.01 atm. The results of this test are shown in Table II.

#### Detailed Description Text - DETX (22):

A composite hollow fiber module of essentially the same as that described in Example 3 was made except that the module contained 38 fibers with inside diameters of 365 .mu.m and having 166 cm.sup.2 of surface area and inside surfaces were coated with a cross-linked PVA. This module was operated in a vapor permeation test on a feed mixture of 16 wt % water in MeOH at 77.degree. C. and a feed pressure of 1.1 atm. The permeate pressure was maintained at 0.1 atm. In addition, a condensable sweep stream comprising 100% MeOH at 75.degree. C. and 0.1 atm was introduced to the permeate side of the at a sweep inlet port located near the retentate end of the module so as to flow countercurrent to the flow of the feed.

#### Detailed Description Text - DETX (23):

Under the operating conditions described above, the combined permeate side mixture had a water concentration of 66 wt %, resulting in an enrichment factor (ratio of water concentration in the permeate to water concentration in the feed) of 4.1. The water flux through the was 6 kg/m.sup.2 .multidot.day.

Detailed Description Text - DETX (24):

For comparison, the module was operated under the same conditions without the countercurrent condensable sweep stream. In this experiment, the feed solution comprised 11 wt % water in MeOH and the permeate pressure was set at 0.01 atm. In this case the water flux through the                      was only 3 kg/m.sup.2 .multidot.day--only half of the water flux obtained using a countercurrent condensable sweep, while the enrichment factor was 4.5, even though the system was operated with a permeate pressure that was 10 times lower than that used with the countercurrent condensable sweep.

Detailed Description Text - DETX (28):

The module of Example 7 was operated in a vapor permeation test using a feed stream consisting of 670 ppm benzene in hexane at 90.degree. C. fed at a rate of 3.0 g/min to the lumens of the hollow fibers at a pressure of 1.0 atm. A condensable sweep stream comprising 100% hexane at 90.degree. C. and 0.1 atm was introduced to the permeate side of the                      at a sweep inlet port located near the retentate end of the module so as to flow countercurrent to the flow of the feed. The flow rate of the hexane vapor sweep was set at 0.2 g/min.

Detailed Description Text - DETX (29):

A combined permeate side mixture comprising the condensable vapor sweep stream and the benzene that selectively permeated the                      was withdrawn from the permeate outlet port located near the feed end of the module. Under these operating conditions, the benzene flux through the                      module was 0.17 kg/m.sup.2 .multidot.day.

Claims Text - CLTX (3):

(b) a bundle of thin film composite hollow fiber                      arranged substantially parallel to each other in said chamber, each of said composite hollow-fiber                      comprising:

Claims Text - CLTX (6):

(c) means for securing and sealing said bundle of hollow fiber                      to said chamber at said feed and retentate ends so as to permit fluid communication with said feed gas.

Claims Text - CLTX (7):

2. The module of claim 1 wherein said feed stream is directed to the inside of said composite hollow fiber                      .

Claims Text - CLTX (8):

3. The module of claim 1 wherein said feed stream is directed to the outside of said composite hollow fiber

Claims Text - CLTX (11):

6. The module of claim 1 wherein said hollow fiber comprises a polymer having pendant or terminal ethynyl groups, the polymer being selected from the group consisting of polyethersulfones and polyetherimides.

Claims Text - CLTX (36):

25. The module of claim 23 wherein said permselective coating comprises a blend of a polyvinyl alcohol and a polyethyleneimine cross-linked with ethyl

Claims Text - CLTX (44):

(a) contacting a vaporous feed stream containing a first vapor and at least one additional vapor with the feed side of thin film composite hollow fiber arranged substantially parallel to each other in a chamber having a feed end and a retentate end, each of said composite hollow fiber comprising:

Claims Text - CLTX (47):

(b) permitting said first vapor in said feed stream to permeate from the feed side to the permeate side of said hollow fiber to form a permeate stream enriched in said first vapor and a retentate stream depleted in said first vapor; and

Claims Text - CLTX (49):

33. The process of claim 32 wherein said feed stream is directed to the inside of said composite hollow fiber

Claims Text - CLTX (60):

44. The process of claim 32 wherein said feed stream is directed to the outside of said composite hollow fiber

Claims Text - CLTX (63):

47. The process of claim 32 wherein said hollow fiber comprises a polymer having pendant or terminal ethynyl groups selected from the group consisting of polyethersulfones and polyetherimides.

Claims Text - CLTX (79):

(a) contacting a vaporous feed stream containing a first vapor and at least one additional vapor with the feed side of thin film composite hollow fiber

arranged substantially parallel to each other in a chamber having feed and retentate ends, means for introducing a sweep stream at the retentate end of said chamber and means for removing permeate at the feed end of said chamber, each of said composite hollow fiber comprising:

Claims Text - CLTX (82):

(b) directing a sweep stream to the permeate side of said hollow fiber by said means for introducing a sweep stream in a manner such that the flow of said sweep stream is substantially countercurrent to the flow of said feed stream, thereby transporting at least a portion of said first vapor from said feed side to said permeate side of said to form a combined permeate side mixture of said sweep stream and said first vapor;

Other Reference Publication - OREF (2):

Suemsatsu et al., "Separation of Ethanol-Water Mixtures by Vapor Permeation Through Cellophane " 14 337 (1989).